Aquaculture in Canada

BP-156E

Backgrounder

Aquaculture in Canada

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Science and Technology Division

6 October 1986

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Cat. No. YM32-2/156E

ISBN 0-660-12474-2

CANADA

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THE FUTURE OF AQUACULTURE IN CANADA

INTRODUCTION

Fishing has remained, despite the steady advance of technology, a primary form of marine resource exploitation. Today as yesterday, aquatic species are cultivated out of a purely practical wish to progress beyond the stage of random harvesting, which is often insufficiently productive. Although aquaculture in a general sense has been practised for thousands of years, it was not until 1890-1900 that it was placed on a scientific footing by American, English, French, Norwegian and Danish biologists who turned their attention from freshwater pisciculture to the sea.(1,2) At the same time, a few pioneers of aquaculture were trying to raise lobster and cod on the east coast of Canada.(3)

Since then, this field has expanded greatly, and at present 10 to 12% of world marine output, or some 100 million metric tonnes, comes from aquaculture enterprises. China (with 2.5 million tonnes in 1984) and Japan (with 1 million tonnes in 1984) remain undisputed masters in the art of raising and cultivating aquatic organisms. International aquacultural output grew phenomenally by some 67% between 1975 and 1984. In the same period, several countries that compete with Canada in fishing and that have a climate similar to ours substantially increased their aquacultural

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(1) France, Conseil économique et social, "L'Aquaculture", Journal officiel de la République française, sessions of 24 and 25 November 1981, No. 4, Paris, February 16, 1982, p. 157.

(2) Jean-Pierre Amyot, Aquaculture: an Activity with Surprising Potential, Background Paper for Parliamentarians No. BP-73E, Library of Parliament, August 2, 1983, 36 p.

(3) T.G. Carey, Department of Fisheries and Oceans, personal communication, Ottawa, 1986.

production. Among these are the United States (340%), Norway (1,000%), France (22%) and Japan (6%).(4)

While aquaculture harvests have tended lately in Canada to stagnate at 6,000 tonnes, marked enthusiasm has recently overcome the indifference of many investors, and major development projects have been introduced in both Eastern and Western Canada.

Although aquaculture goes back thousands of years, industrial production of marine resources for human consumption is a comparatively new concept in North America. Canada's harsh climate and relative abundance of resources have always militated against the development of aquaculture businesses. Now, however, such factors as the levelling off (or even decrease) of commercial catches and shifts in consumers' food preferences toward fish products have heightened interest and strengthened support for the development of aquaculture for food.(5)

It is difficult, we must acknowledge at this point, to make a clear semantic distinction between aquaculture for consumption and aquaculture for resource enhancement, particularly in the case of the salmonids. Canadian scientist D.E. Aiken describes the problem in these terms:

> Salmon released from a government hatchery to augment stocks are clearly intended to enhance the resource. Salmon released from a private hatchery for sea ranching are clearly intended for human food, yet many of these disappear into the capture and sport fisheries to become part of the resource and thereby enhance that resource. Both groups of salmon are produced as food for human consumption, one by a private interest for its own profit, the other by public interest for the profit of others. Profit is

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(4) Canada, Department of Fisheries and Oceans, Private Sector Aquaculture Production and Value in Canada: an Overview, Ottawa, 1986, p. 6.

(5) D.E. Aiken, "Aquaculture in Atlantic Canada", in G.I. Pritchard (ed.), Proceedings of the National Aquaculture Conference, Strategies for Aquaculture Development in Canada, Canadian Special Publication of Fisheries and Aquatic Sciences No 75, Ottawa, 1984, p. 6-15.

> therefore the distinguishing feature, not food. And the situation is no less complex in the freshwater environment. Trout from public hatcheries stocked in public ponds for sport fishing by fee-paying licensees are only marginally different from those purchased from private hatcheries and stocked in private ponds for pay-as-you-catch sportsmen. Those stocked in a pothole to be harvested for personal use may easily be bartered to a neighbor or sold outright from the bank of the pond. The variations are many and the distinctions probably meaningless.(6)

The scope of our study must be limited, and hence we shall disregard fish-raising activities geared to resource enhancement, such as the Salmonid Enhancement Program on the Pacific Coast (SEP), government hatcheries and the breeding and rearing of aquarium species or subjects for laboratory experiments. Our study will attempt to give a brief overview of the present status of aquaculture in Canada, with special attention to the outstanding potential of British Columbia waters.

CANADIAN AQUACULTURE

A. Present Status

There are approximately 2,200 commercial aquaculture establishments in Canada. About half of these raise oysters. Salmon and mussels on both coasts and trout in Quebec, Ontario and the Prairies offer the best opportunities in this young industry. Given that a yield of 6,000 tonnes represents $15 million to the producer,(7) we can confidently project that potential sales of aquacultural products could rise to several hundred million dollars in the medium term.(8)

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(6) Ibid., p. 7.

(7) J.M. Anderson, "Aquaculture: the New Wave in Farming", Agrologist, Vol. 14, No. 2, Spring 1985, p. 26.

(8) Report of the Proceedings, National Aquaculture Conference, sponsored by the Department of Fisheries and Oceans and the Science Council of Canada, Ottawa, 1983, p. 2.

Our neighbours to the South have already attained an annual output of some 190,000 tonnes, worth over $440 million. John M. Anderson of the Atlantic Salmon Research Institute in St. Andrews, New Brunswick, reports that our northern climate is not the primary factor in keeping our production far behind US yields. The success of coldwater aquaculture in some European countries suggests we are not exploiting our opportunities. Norway, for example, sold about 20,000 tonnes of Atlantic salmon in 1984, worth close to $200 million. Norway is projecting a production of 80,000 tonnes by 1990, which will create 50,000 new jobs directly and another 50,000 in the support industries.

According to J.M. Anderson, the Canadian aquaculture industry at present is at three stages:

(i) species that have progressed to being raised or cultivated commercially:
- oysters - American (Crassostrea virginica)
  - European (Ostrea edulis)
  - Pacific (Crassostrea gigas)
- blue mussels (Mytilus edulis)
- rainbow trout (Salmo gairdneri)
- brook trout (Salvelinus fontinalis)
- salmon - coho (Oncorhynchus kisutch)
  - chinook (Oncorhynchus tshawytscha)
  - Atlantic (Salmo salar)
- bluefin tuna (Thunnus thynnus)

(ii) species being raised or cultivated in pilot projects:
- clams (Spisula solidissima, Venus mercenaria, etc.)
- abalone (Haliotis kamtschatkana)
- American lobster (Homarus americanus)
- sable fish (Anoplopoma fimbria)
- Pacific herring (grown for roe) (Clupea pallasii)
- Irish moss (Chondrus crispus)

(iii) species being raised or cultivated experimentally:
- scallops (Pecten sp.)
- crayfish (Cambarus affinis)
- eels (Anguilla sp.)
- sturgeon (Acipenser sp.)
- Arctic char (Salvelinus alpinus)
- laminaria (algae) (Laminaria sp.)(9)

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(9) Anderson (1985), p. 26.

The reasons that have so far attracted growing interest to aquaculture in Canada may be listed as follows:

- its demonstrated success in many other countries;
- a strong and increasing market demand in Canada and export markets for an assured supply of quality fresh fish and seafoods;
- opportunities in Canada for the replacement of aquaculture imports (e.g. Norwegian salmon and Idaho trout);
- the employment and income which aquaculture generates, particularly in small coastal communities, as well as in a number of inland communities;
- the challenge of developing and applying the advances of science and technology to improve the quality of a basic resource and create new economic opportunities;
- new developments in R&D, fish health and feed supply which have demonstrated the viability of the aquaculture of certain species (e.g. lobster)
- the growing interest in pay-angling aquaculture of freshwater fish near metropolitan centres;
- the recognition of the role for aquaculture in providing stock for wild fisheries;
- interest in the contribution that aquaculture can make to the support of the recreational and Native fisheries.(10)

Aquaculture has become one of the few food sectors that seem to offer significant growth potential. Some 80 to 90% of the Canadian aquacultural industry's output is now consumed domestically. About 10% is sold to the United States (trout, salmon and oysters). The federal Department of Fisheries and Oceans recently determined the sales potential of some species over the next decade (see Table 1). We note that Atlantic and Pacific salmon should be leading growth areas on both domestic and foreign markets. Thus, by implementing effective commercial strategies,

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(10) Canada, Department of Fisheries and Oceans, Developing Aquaculture in Canada: A Discussion Paper, Ottawa, January 1986, p. 6.

Table 1: Medium-term Sales Potential

Species	Estimated production in 1984 (in metric tonnes)	Estimated potential sales in 1990 (in metric tonnes)
Blue mussel	950*	2,000*
Trout	1,850	2,500
Salmon - Atlantic	300	2,000
- Pacific	100	2,000
Oyster	2,800*	6,000*
Tuna	50	N.A.
TOTAL	6,000	14,500

* Weight in shell.

Source: Canada, Department of Fisheries and Oceans, Developing Aquaculture in Canada: A Discussion Paper, Ottawa, January 1986, p. 7.

Canada could meet competition (mainly from Norway and the USA) and by 1990 sell half its farmed salmon to US consumers. Indeed, because of its size and proximity, the US market affords the greatest potential for Canadian aquaculture products. In the long term, Atlantic and Pacific salmon, oysters and mussels are expected to hold the best potential for large-scale increases in sales volume.(11) For reference, Table 2 shows figures on the volume and value of Canadian commercial aquaculture in 1983. Note that this information includes data on the output and value of pond angling.

Developing aquaculture in Canada has not been plain sailing. Problems with capital, lack of manpower, an inappropriate legal framework, technical and scientific difficulties and strong opposition from certain fishermen's organizations and individuals hamper the establishment of the structures necessary to allow the industry to take off. Although every region of the country has its own characteristics, British Columbia, with its long shoreline and its many fisheries, is a good example of the complexity and scope of this new "Klondike". In the pages that follow, we shall thus try to describe in brief the factors that shape the growth of this commercial activity in Canada.

B. The Hesitant Beginnings of an Industry

British Columbia's waters are rich in molluscs, crustaceans and finfish. Hitherto, however, few species have sustained a profitable yield in commercial aquacultural enterprises. Aquaculture is known as a high-risk business, especially in the initial phases of an enterprise.(12) As with any commercial venture, the basic problem for the development of aquaculture is how to generate enough income relative to the investment required. Many factors come into play, notably operational efficiency, use of competitive techniques and market conditions. But

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(11) Ibid., p. 7-8.

(12) Richard L. Saunders, "Reduction of Risks in Canadian Aquaculture through Application of Biological Research", in G.I. Pritchard (1984), p. 70.

Table 2: Aquaculture Production and Value in Canada (1983)

	British-Columbia		Prairies		Ontario		Quebec		Maritimes		Newfound-land		Canada	
	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V
Atlantic Salmon	-	-	-	-	-	-	-	-	127	1,051	30	130	157	1,181
Pacific Salmon	129	670	-	-	-	-	-	-	-	-	-	-	129	670
Trout	84	480	140	550	750	3,000	285	2,000	170	690	30	150	1,459	6,870
Tuna	-	-	-	-	-	-	-	-	60	280	-	-	60	280
Oysters	2,210	1,768	-	-	-	-	-	-	900	830	-	-	3,110	2,598
Mussels	-	-	-	-	-	-	-	-	272	360	150	180	422	540
Total	2,423	2,918	140	550	750	3,000	285	2,000	1,529	3,211	210	460	5,337	12,139

Q: Quantity of finished product in metric tonnes
V: Value in $Can 000.

Source: Canada, Department of Fisheries and Oceans, Private-Sector Aquaculture Production and Value in Canada: An Overview, Ottawa, January 1986, p. 10.

above all, according to two scientists, R.H. Cook and R.E. Drinnan:

> Many of the significant constraints to aquaculture in Canada are derived from the lack of definition of the status of aquaculture and its acceptance, socially and officially, as parallel to other food producing systems and therefore meriting similar treatment. This results in a lack of a basis on which to assign appropriate priorities for establishing support mechanisms and structures and solutions to the more obvious constraints, or strategies to develop these.(13)

The same researchers also maintain that all aquaculture operations have certain features in common which are at the root of the complexities in their establishment, maintenance and expansion.

- They use a common property resource subject to a number of legal controls, diverse jurisdictions and a common public assumption of free access, namely water, be it from the ground or a stream, an estuary or the ocean.

- They employ native species, usually of high unit value and demand, which are the traditional target of commercial or sport fisheries, or exotic, introduced species. Each poses special problems and potential threats, real or perceived, to the social and ecological status quo.

- With the exception of a very few well established culture practices, aquaculture is a new concept often associated with "outside business" interests and viewed with suspicion by a largely conservative rural population, jealous of its traditional rights.(14)

In theory, every aquaculture project should, in so far as possible, be introduced in the location best suited for it and with a minimum of undesirable effects on other fishing and recreation. The federal government's constitutional mandate as regards the location of

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(13) R.H. Cook and R.E. Drinnan, "Planning for Aquaculture Development in Canada: A Maritimes Perspective", in G.I. Pritchard (1984), p. 80.

(14) Ibid., p. 79.

an aquaculture business has two aspects: on the one hand, projects may involve federal public property, such as national parks and certain public harbours; on the other hand, an aquaculture business may come into conflict with other activities or areas under federal jurisdiction, such as navigation, fisheries, land subject to territorial claims and Indian reserves. At the same time, in most cases the provincial governments are responsible for issuing permits giving aquaculturists ownership or lease of submerged land.(15) According to Professor Bruce H. Wildsmith of Dalhousie University's Faculty of Law, many ambiguities result from handling aquaculture in the same way as fishing, particularly as regards the involuntary application to aquaculturists of catch limits and restrictions on periods of activity.(16) In his view, the federal government's role in the aquaculture industry (see Table 3) undoubtedly needs to be defined more clearly. To this end, he proposes setting up an aquaculture development council to plan the industry's development at the national level. Composed of representatives of the industry and the federal and provincial governments, the council would ensure that the regulations arising out of a National Aquaculture Act were observed.(17)

The fears and objections voiced in regard to aquaculture in British Columbia touch on the following issues: water pollution, use of antibiotics in the ocean, unpleasant smells, decrease in property values near aquacultural operations and siphoning of funds and labour

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(15) Bruce H. Wildsmith, "Federal, Provincial, and Municipal Government Roles in Aquaculture", in G.I. Pritchard (1984), p. 104-112.

(16) Bruce H. Wildsmith, Federal Aquaculture Regulation, Canadian Technical Report of Fisheries and Aquatic Sciences No. 1252, Ottawa, April 1984, 89 p.

(17) Toward an Appropriate Federal Aquaculture Role and Legislative Base, Canadian Technical Report of Fisheries and Aquatic Sciences No. 1419, Ottawa, December 1985, 88 p.

Table 3: Federal and Provincial Government Roles in Aquaculture in Canada

TOPIC	GOVERNMENT	BASIS OF JURISDICTION
1. Physical location		
A. Linkage to provincial and municipal planning	Provincial	Property and civil rights (s. 92(13))
B. Linkage to shipping and navigation	Federal	Shipping and Navigation (s. 91(10))
C. Rights to surface land	Provincial (assuming not federal lands)	Property and civil rights
D. Rights to sub-aquatic land and water space within provincial boundaries (leasing)	Provincial (assuming not federal lands)	Property and civil rights
E. As D but outside provincial boundaries	Federal	Peace, Order and Good Government (s.91) and Supreme Court of Canada (SCC) decisions and federal public property (s. 91(1A))
F. Use of water within provincial boundaries	Provincial (putting aside question of interprovincial and international waterways)	Property and civil rights
G. As F but outside provincial boundaries	Federal	Peace, Order and Good Government (s.91) and S.C.C. decisions and federal public property
H. Construction of facilities	Provincial	Property and civil rights
2. Organisms		
A. Introduction of species	Federal and Provincial	Fisheries (s. 92(12)) and Property respectively
B. Supply of - commercial - wild	 Provincial Federal	 Property and civil rights Fisheries

Table 3: Federal and Provincial Government Roles for Aquaculture in Canada (continued)

C. Property rights in organisms within provincial boundaries	Provincial	Property and civil rights
D. Property rights in organisms outside provincial boundaries	Federal	Peace, Order and Good Government
E. Fishing For	Federal	Fisheries
F. Transport - within province	Provincial and Federal	Property and civil rights and fisheries respectively
- out of a province	Federal	Trade and commerce (s.91(2)) and Fisheries
G. Sale - within a province	Provincial	Property and civil rights
- out of a province	Federal	Trade and commerce
H. Inspection - Fish Health	Both or Federal	
I. Escape	Both or Federal	
J. Predator Control - marine & migratory birds	Federal	Fisheries and Empire Treaty (s. 132)
- land & air	Provincial	Property
K. Feed	Provincial	Property
L. Theft	Federal	Criminal Law

Table 3: Federal and Provincial Government Roles for Aquaculture in Canada (continued)

3. **Ranching, especially in travelling outside province**	Federal	Fisheries, Peace, Order and Good Government, and federal public property
4. **Marketing & Processing**		
- for sale within province	Provincial	Property and civil rights
- for sale outside province	Federal	Trade and commerce
5. **General licensing**	Provincial	Various
6. **Insurance**	Both	Spending powers
7. **Pollution**		
- protection from	Provincial	Property and civil rights
- as a source of	Both	Property and fisheries
8. **Loans, Taxation, Pilot projects, R&D, and other stimulative measures**	Both	Various, but basically powers of taxation and unlimited spending ability (in constitutional sense)
9. **Statistics**	Both	

Source: Canada, Department of Fisheries and Oceans, Developing Aquaculture in Canada: A Discussion Paper, Ottawa, January 1986, p. 13-14.

traditionally employed to improve such marine species as salmon.(18,19) It should be emphasized that the strongest opposition comes from fishermen, whose concerns are conveyed by many spokesmen, including the powerful United Fishermen and Allied Workers' Union (UFAWU).(20) This group maintains that encouraging salmon farming may lead to tighter restrictions on fishermen who catch fish in their natural state. According to UFAWU, if sea ranching and fishing boundaries are introduced, common property may eventually be abolished:

> This all implies elimination of the common property fishery, on which the commercial and sport fishing industries now depend. Alienation of fish from the public to private domain would end that existing industry for questionable benefits. These benefits likely would flow only to large and possibly foreign-owned corporations. Yet title to the fish is essential if aquaculturists are to secure bank loans and develop along conventional corporate lines.(21)

One of the main differences between traditional fishing and aquaculture has to do with common property. Aquaculture cannot be based on a commonly owned resource. An analogy can be drawn with the development of agriculture in the eighteenth century, when, coupled with the demand stimulated by the industrial revolution, the enclosure movement gave birth to modern agriculture and infinitely more efficient production technology.

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(18) "Conference on Aquaculture Probes Threat", The Fisherman, Vancouver, June 23, 1986.

(19) "Can Fishermen, Fish Farms Co-Exist?", The Fisherman, Vancouver, July 23, 1986.

(20) "Fish Farms: A Bad Idea Getting Worse", The Fisherman, Vancouver, August 16, 1985.

(21) Davin Karjala, Deep Bay Local 23, UFAWU, Proceedings and Evidence of the House of Commons Standing Committee on Fisheries and Forestry, Issue No. 24, March 30, 1985, p. 210.

The stimuli at work then seem to have been the same as those we now see in the fishing sector.(22)

Peter H. Pearse, after studying the vexed question of property law, suggested granting leases that would give aquaculturists rights to a specific geographic area. This proposal is the logical outcome of the following line of thought:

> The progression from unrestricted licensing, to limited-entry licensing, to quota licensing represents successively more clearly defined privileges granted to resource users. A further step in this progression involves issuing rights to individual fishermen or groups to the resources in a prescribed area. The rights take the form of leases; like grazing leases, trapping licences or forest management licences, they confer exclusive rights to fisheries resources over defined areas.(23)

As Pearse emphasizes, this process does cause particular problems for those who raise highly migratory species liable to interception by fishermen outside the lease areas. Moreover, he adds, "if the areas were large, such leases might threaten established commercial fishermen in the region or tend to create local monopolies."(24)

Apart from the thorny debate surrounding the establishment of aquaculture stations, the matter of investment capital sources has also provoked much comment. The large investments required, the lack of any clear government policy and the high risk characteristics discourage Canadian investors from supporting aquaculture. According to the Science Council of Canada, the industry must depend for its success on a nucleus of integrated, independent corporations and cooperatives. Only when large companies are firmly established will smaller ventures be able to prosper.

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(22) Kenneth C. Lucas, "Aquaculture in Canada: Getting our Act Together", in G.I. Pritchard (1984), p. 2.

(23) Peter H. Pearse, Turning the Tide: A New Policy for Canada's Pacific Fisheries, Commission on Pacific Fisheries Policy, Vancouver, September 1982, p. 84.

(24) Ibid., p. 85.

Canada thus has to seek out a judicious combination of Canadian and foreign capital.(25) On the entry of foreign companies and big business, Ward Griffioen, operational manager of Seastar Resources Corporation, puts forward a strong argument:

> ... I have been looking for funding in Canada for the last six years to get this going. It was not until the foreigners came in and started to think about walking away with our resources that Canadians became interested in investing in aquaculture. Definitely there is a role. If these people come in with some expertise and they can get this sort of thing rolling quicker, I would say okay. And I think we should not be too threatened by them; if it were not for them aquaculture would not be anywhere, because it was actually when they started to come in here and show this interest that the thing started rolling.(26)

An Industry Task Force on Aquaculture sponsored by the Science Council of Canada recently proposed the creation of regional aquaculture coordinating committees (RACCs). These should have equal representation from private sector producers and concerned provincial and federal departments. One of the prime functions of RACCs would be to determine sources of fiscal aid to the industry and advise on the application of this aid to achieve commercial-scale development.(27) The Science Council of Canada itself also made a recommendation on this matter:

> that governments direct their lead agencies for aquaculture to coordinate funding from all sources and, with the advice of the Regional Aquaculture Coordinating Committees recommended by the Industry Task Force, channel funds into development of the

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(25) Science Council of Canada, Aquaculture: An Opportunity for Canadians, Ottawa, March 1985, p. 18-19.

(26) Ward Griffioen, Seastar Resources Corporation, Proceedings and Evidence of the House of Commons Standing Committee on Fisheries and Forestry, Issue No. 24, March 30, 1985, p. 157.

(27) Industry Task Force on Aquaculture, Aquaculture: A Development Plan for Canada, sponsored by the Science Council of Canada, August 1984, p. 17.

species identified as having the greatest commercial potential in each region.(28)

The science and technology aspect is extremely important for reducing the risks inherent in aquaculture. Much research needs to be done in the fields of health, nutrition, genetics, physiology and engineering. To take only one case, pathology: keeping members of the same species abnormally close together induces behavioural stress that produces physiological changes which lower the organism's resistance to infection. Once pathogens are introduced into a population under stress, they may easily produce a fullscale epidemic. The most obvious way of avoiding disaster is to create ideal growing conditions and prevent all pathogens from reaching the population through recently introduced animals, water or food, or through workers and their tools.(29) In practice, this is of course no easy matter. For example, in summer 1986, when salmon farming was flourishing in British Columbia, the blooming of the microscopic alga known as heterosigma forcibly reminded many farmers of the latent presence of sources of infection in water. In a few short days, thousands of farmed trout and salmon died in saltwater enclosures in the Sechelt region.(30)

DEVELOPMENT PROSPECTS IN BRITISH COLUMBIA

With its 27,000 kilometres of coastline, British Columbia certainly has a valuable asset for developing a flourishing aquaculture industry. In freshwater aquaculture, trout farming and hatcheries(31)

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(28) Science Council of Canada (1985), p. 18.

(29) Saunders (1984), p. 70-77.

(30) Dave Margoshes, "Thousands of Fish Killed as Plankton Chokes Farms", Vancouver Sun, July 2, 1986, p. A-3.

(31) A hatchery is an aquacultural establishment devoted to breeding stock and obtaining larvae and alevins.

remain the most promising. In saltwater (mariculture), the greatest opportunities are to be found in salmon and oyster farming. Other species also offer attractive breeding potential. According to a recent study sponsored by the Science Council of British Columbia,(32) the farming of several species could be economically viable within the next ten years. After assessing their markets, the likelihood of solving technical and biological problems, and their potential profitability over the next decade, the study divided 18 species into three levels of priority (high, medium and low), in order to establish guidelines for granting research and development funds for farming. Among the species which rate immediate attention together with salmon and oysters are freshwater rainbow trout(33) and herring. Though still in its infancy, British Columbia's aquaculture production could reach a value of $150 million by 1995, creating jobs for 3,500 people.(34) (See Figure 1)

At present, British Columbia is probably the province where aquaculture, and especially salmon farming, is making the most dramatic gains in the whole country. Mariculture operating licences were issued at the rate of more than one a day in the early part of 1986. As of March 27, 1986, 113 mariculture sites had been approved and 155 applications were pending. About 40 salmon farms appear to be operating at various locations along the coast. There are three major focal points for mariculture development in the province: the Sunshine Coast, the Quadra Island-Cortez area and the central west coast of Vancouver Island.(35)

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(32) Envirocon Ltd., Potential For Viable Aquaculture: Endeavours in British Columbia, study prepared for the Science Council of British Columbia, Vancouver, March 1984, p. i-iv.

(33) For more information on freshwater trout farming, see British Columbia, Ministry of Agriculture and Food and Ministry of Environment, Freshwater Trout Farming in British Columbia, Victoria, July 1985, 14 p.

(34) British Columbia, Ministry of Agriculture and Food, Aquaculture in B.C.: Getting Started, Victoria, May 1986, p. 2.

(35) Davin Karjala, "Aquaculture: The Boom Out of Control", The Fisherman, No. 6, June 23, 1986, p. 12.

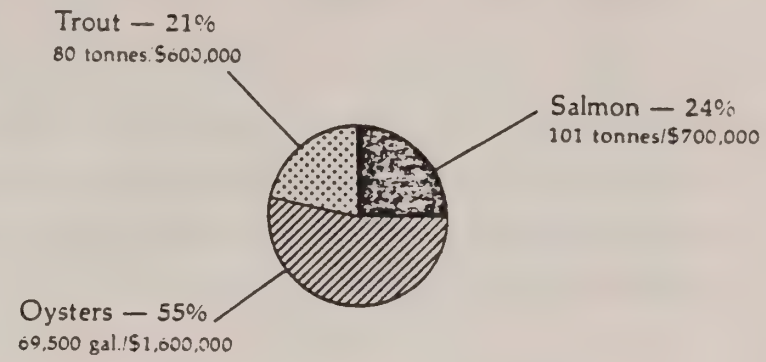
Figure 1

1984

British Columbia

Aquaculture Production

TOTAL $2.9 Million

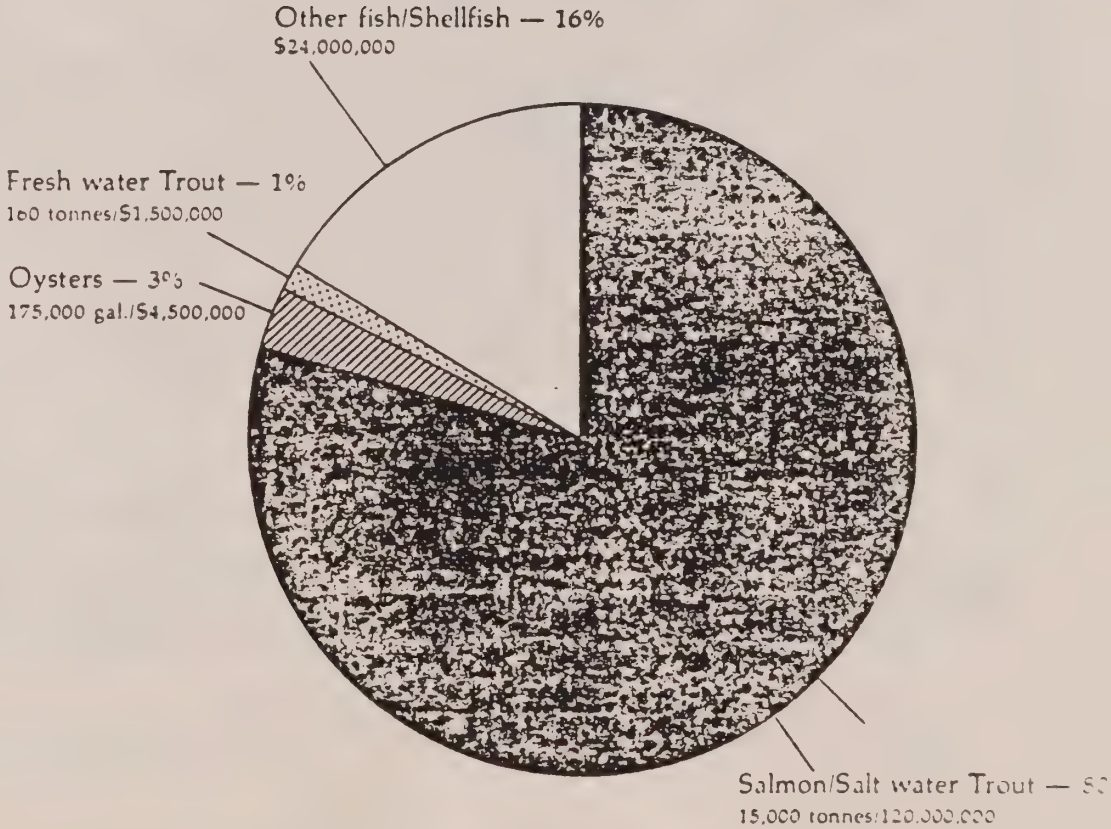


1995

British Columbia

Projected Aquaculture Production

TOTAL $150 Million



Source: British Columbia, Ministry of Agriculture and Food, Aquaculture in B.C.: Getting Started, p 3.

The explosion of aquaculture along the Sunshine Coast inspires both wonder and fear at the degree of interest in salmon farming. In 1985, 17 farms were operating. Since then, 15 more have sprung up, for a total of 32 in 1986.(36) The average investment required to start up such an operation is over $330,000.(37) Recent statistics show that over 3.3 million salmon and trout are now being raised in enclosures with a volume of 272,000 cubic metres, for a production capacity of 2,100 tonnes of fish.(38)

A. Salmon

In addition to giving some attention to sea trout and Atlantic salmon, British Columbia fish farms raise three species of Pacific salmon of the Oncorhynchus family: coho (O. kisutch), chinook (O. tshawytscha) and chum (O keta). The first private fishfarm licence was issued in 1971. Since then, with a solid foundation in freshwater salmon culture, farmers have weathered a series of failures which have still not damped their enthusiasm. Factors in support of this outlook include:

> (1) greater attention to the selection, treatment and quality of eggs supplied and/or the development of brood stock, (2) the possibility of domesticated "sea trout" (rainbow trout) diversifying production and extending the annual use of hatchery equipment, (3) slow but steady advancement in nutrition for marine stages, finishing diets, and in disease control, (4) assessment of smolt quality prior to saltwater transfer, and (5) the start of experimental breeding supported by genetic research eventually leading to domesticated strains of Pacific salmon. There is a trend now to grow larger fish than pan-size (given

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(36) "Aquaculture Conference Reveals Industry Figures", The Press, Sechelt, September 9, 1986.

(37) "Aquaculture Stats Show 270 New Jobs on Coast", The Press, Sechelt, September 3, 1986.

(38) "Aquaculture Conference Reveals Industry Figures", The Press, Sechelt, September 9, 1986.

> good survival), choosing the best time for marketing when fresh-caught wild salmon are not readily available, and diversifying through smoked and packaged products.(39)

This optimism is also rooted in the strength of the salmon market and its achievements in other countries, for world farmed salmon production rose to over 40,000 tonnes in 1984. Norway now leads the world in commercial output, having risen from 1,000 tonnes in 1975 by a factor of 30, to 30,000 tonnes in 1985. Moreover, world production of farmed salmon is expected to continue rising, together with the number of countries that engage in it. In the short term, output could rise to 50,000 tonnes, and in ten years at most, it could represent ten per cent of the total value of salmon harvested.(40)

The varieties favoured by most Pacific farmers are coho and chinook. A few years ago, a typical farmed salmon weighed about 300 grams (11 oz.) and thus had to spend about eight months in salt water. Today, because farming techniques have improved and there is a demand, many businesses have a two-year cycle for coho salmon, which produces a 1.5 kg (3 lb.) fish. Producers wishing to supply the market for even larger salmon raise chinook, which, though harder to rear than coho, may reach over 5 kg (11 lb.) after three years in a netpen.(41)

In its first year of operation, a salmon farm normally runs on the scale of a pilot project, with perhaps four netpens holding about 15,000 fish (see Figure 2). After determining that the project is feasible, the farmer has to achieve an annual production capacity in the order of 50 to 100 tonnes of fish. It is estimated that by the year 2000,

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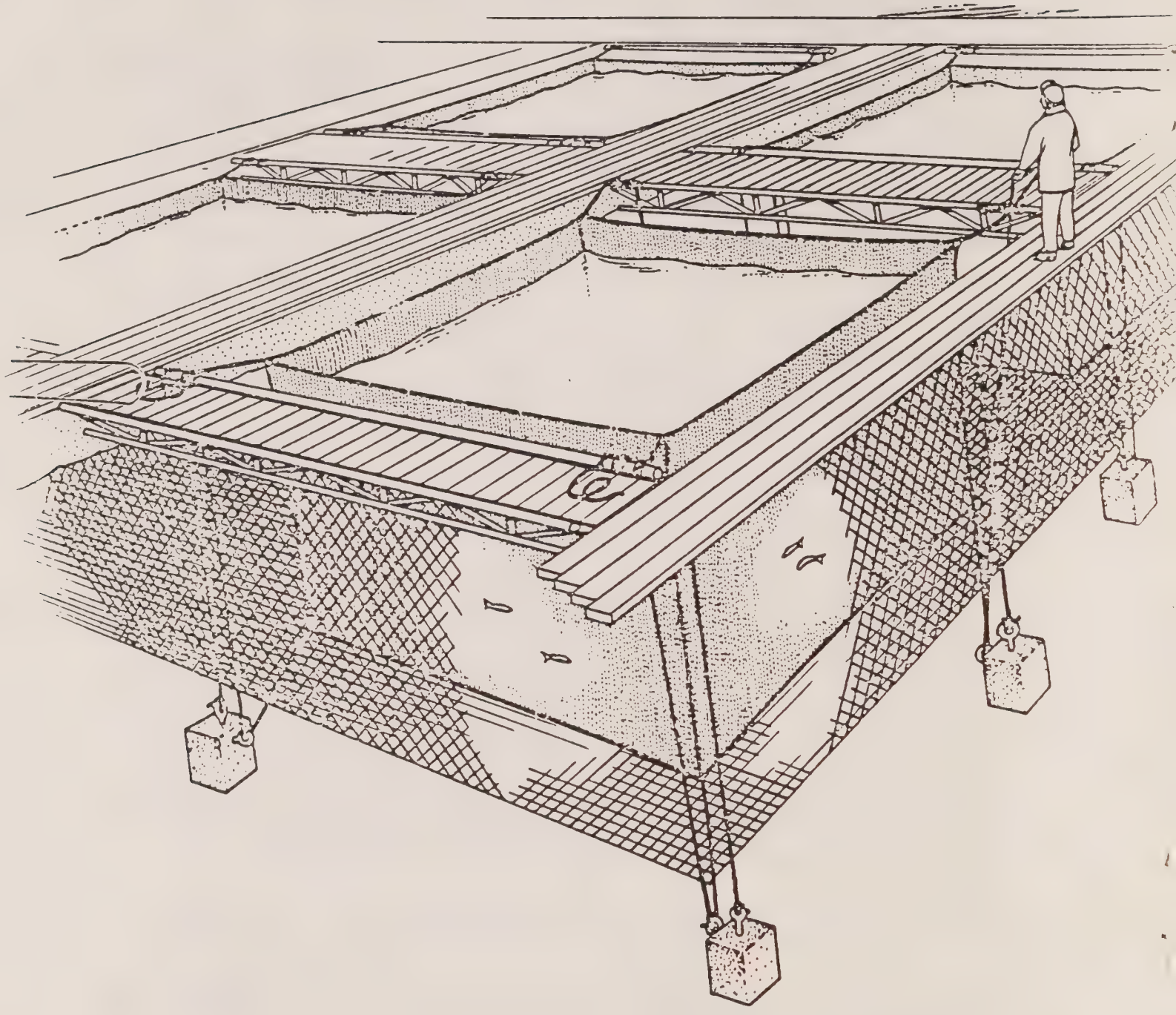
(39) Neil Bourne and J. Roly Brett, "Aquaculture in British Columbia", in G.I. Pritchard (1984), p. 33-34.

(40) N. Endo, "On the Commercial Coho Salmon Culture", Report of the Proceedings of the Salmonid Workshop to Discuss Biological and Economic Optimization of Smolt Production, Tokyo, January 1985, p. 146.

(41) British Columbia, Ministry of Agriculture and Food, Aquaculture in B.C.: Getting Started, p. 6.

Figure 2: Salmon Farm Float and Netpen



Source: British Columbia, Ministry of Agriculture and Food, Aquaculture in B.C.: Getting Started, p. 5.

salmon farming will create 2,000 jobs in British Columbia and generate an annual yield worth about $122 million.(42)

By as early as 1988, the projected output of 10,000 to 12,000 tonnes of farmed salmon will be 39 to 47 times as great as the 1985 yield (250 tonnes). This sharp increase, however, raises two types of concerns among British Columbia salmon farmers: (1) can the international market absorb such production increases? and (2) what prices will farmed salmon fetch? At present there is no clear indication of the market's saturation point, nor of when that is likely to be reached. More certain, however, is that Norwegian farmed salmon is flooding the markets of many countries, including our principal trading partner, the United States. Norway is steadily increasing its farmed salmon output,(43) and thereby showing that producing a high-quality fresh fish that pleases consumers' tastes offers great possibilities.(44) We should also note that many other countries, such as the United States, Scotland and Chile, are also heavily involved in this exciting adventure of large-scale production of salmon under controlled conditions.

B. Oysters

Invertebrate culture in British Columbia is at present focused on molluscs, and oysters in particular. Three species of oysters are found along the province's shores, and all are fished commercially. The native oyster (Ostrea lurida) is a small mollusc whose slow growth, coupled with high labour costs, probably precludes culture. The Eastern oyster (Crassostrea virginica), although planted each year from 1903 to 1940, did not spread in the province and hence has no potential for culture.(45)

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(42) Ibid., p. 7.

(43) From 1980 to 1985, annual salmon yields increased by 15.5 tonnes in British Columbia and 4,576 tonnes in Norway.

(44) British Columbia, Ministry of Agriculture and Food, The Market for Farmed Salmon: an Overview, June 1986, p. 21.

(45) Bourne and Brett (1984), p. 26.

The oyster industry was born in British Columbia with the introduction of the giant Pacific oyster (Crassostrea gigas) in about 1912. After attaining a volume of 6,195 tonnes in 1963, giant oyster production declined steadily, falling to 1,415 tonnes in 1981. According to N. Bourne and J.R. Brett, this decline is due mainly to underexploitation of concessions, poor husbandry and underseeding. They observe, "If a thriving oyster industry cannot be established in British Columbia it is unlikely that any other marine invertebrate can be cultured economically in the Province."(46)

Today, about 175 oyster producers are growing 70,000 US gallons of oysters on 1,400 hectares of British Columbia foreshore. The demand for oysters in the province clearly reveals the excellent potential for raising this mollusc. Over $6 million dollars worth of fresh, frozen and canned oysters are imported into Canada annually from the United States and Korea. The investment required to set up an oyster operation is in the order of $150,000.(47)

RESEARCH AND DEVELOPMENT

Commercial aquaculture now offers very impressive growth potential in Canada. Obviously, governments must help the industry overcome certain obstacles. Above all, the industry wants the recognition that will enable it to obtain the assistance it needs from financial institutions. Other main concerns for aquaculturists, in addition to clarification of government roles and product marketing, are research and development and transfer of information. Genetics, nutrition, health, physiology, biotechnology and so forth are research subjects whose commercial applications have long been valued outside the laboratories.

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(46) Ibid., p. 28.

(47) British Columbia, Ministry of Agriculture and Food, Aquaculture in B.C.: Getting Started, p. 10.

In the Pacific region of the country, the West Vancouver laboratory belonging to the Pacific Biology Station (PBS) of Fisheries and Oceans Canada has gained an international reputation for its work on aquaculture, genetics and biotechnology.(48,49) An exhaustive analysis of such research, which reflects a new burst of energy, would be far beyond the scope of this study. Nevertheless, we can briefly outline the main objectives of the revolutionary use of certain "new biology" products and techniques. Research into genetic improvement of fish is fairly recent. Its first phase entailed testing the effectiveness of selection and crossbreeding: specimens with desirable hereditary traits were selected to reproduce a given population. More recently, geneticists have striven to manipulate fish reproduction in various ways, thereby creating new methods, such as self-fertilization, in an attempt to upgrade species. Because of these various projects, one of the top priority goals of genetic improvement is to increase resistance to diseases. Another concern with many fish, as with domestic fowl and mammals, is to produce more of one sex than the other. Among salmonids (trout and salmon), for example, females are favoured, because they reach puberty an average of one year later than males and thus do not suffer the negative effects of sexual maturity so early (slower growth due to energy expenditure on forming gonads). Better still, several researchers around the world are now trying to develop methods of postponing puberty indefinitely in fish.(50)

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(48) Canada, Department of Fisheries and Oceans, "Pacific Region: "Organization and Accountability Review", Documentation, Sept. 24, 1986, p. 2.

(49) For more on biotechnology and genetics applied to mariculture, see: Jean-Pierre Amyot, Biotechnology: A Revolution Full of Promise, Background Paper for Parliamentarians, BP-64E, Library of Parliament Ottawa, February 1983, 62 p; J.R. Calaprice, "Mariculture - Ecological and Genetic Aspects of Production", Journal of the Fisheries Research Board of Canada, Vol. 33, 1976, p. 1068-87; Arthur Klausner, "Food from the Sea", Biotechnology, Vol. 3, No. 1, January 1985, p. 27-32.

(50) Daniel Chourrout, René Guyomard and Bernard Chevassus, "L'amélioration génétique des poissons", La Recherche, Vol. 17, No. 180, September 1986, p. 1028-38.

Genetic improvement has thus become an essential element in the development of certain intensive types of farming. Faster growth and giant fish are now possibilities, thanks to the new technique of gene splicing. Research on Atlantic salmon at Memorial University in Newfoundland may make it possible to rear this species in exceptionally cold water. The project involves splicing into salmon eggs a gene encoding a protein which enables other species of fish to live in subzero temperatures.(51,52) The years to come may thus hold great surprises that will no doubt alter the rules that govern the value of some of the marine products on the food market. For example, there are plans to produce giant rainbow trout cheaply to compete with salmon. Furthermore, the fact that private hatcheries such as the Clear Springs Trout Company in Idaho, USA reinvest a large portion of their profits in genetic research evinces its importance as a major factor in the development of aquaculture.(53,54)

CONCLUSION

A recent report by the Senate Standing Committee on Fisheries emphasizes that although to date there has been no serious research into the effects of aquaculture on the traditional fishing industry, it appears that it will have considerable impact on that industry, as the expertise develops. Moreover, the report points out that farmed salmon are already more acceptable than the free-range fish because of their uniform sizing and perceived superior quality. Reduced transportation and harvesting costs and higher return from capital

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(51) Ibid., p. 1038.

(52) Margaret Munro, "Super Species: Who's Minding the Lab?", Nature Canada, Vol. 14, No. 1, Jan.-March 1985, p. 20.

(53) Clear Springs Trout Co. alone produces 7,000 tonnes of rainbow trout, which is 40% of US output.

(54) Chourrout, Guyomard and Chevassus (1986), p. 1029.

investment also militate in favour of what promises to be "the industry of the future".(55)

Praised by some and rejected by others, aquaculture remains an activity full of potential. The mere fact that Norway's farmed salmon is worth more than all British Columbia's commercial fishing catch ($205 million in 1985)(56) indicates that we are not dealing with any pipe-dream. Soon, no doubt, debates about aquaculture will centre not on whether we should be involved in developing it but on how it will advance and how quickly. After the first National Aquaculture Conference in 1983, many working groups were set up to devise mechanisms and strategies for developing aquaculture in Canada, and many aquaculture associations were created or became more active and visible. In this connection, we note the existence of the Aquaculture Association of Canada, whose most recent meeting in Guelph in June 1986 featured papers and discussions on such varied and important topics as marketing aquaculture products, nutrition and disease, Canadian involvement in setting up aquaculture facilities in developing countries, farming technology, handling salmonid reproduction, and so forth.(57) The industry that was embryonic a decade ago can be said to have reached puberty.

Only if all interested parties in industry, research and government work together can the structures and arrangements necessary for the harmonious development of this promising industry be quickly set up. We should note that the federal and Nova Scotia governments recently concluded an agreement that sets precedents for the development of commercial aquaculture. In addition to defining the two parties' responsibilities, the agreement gives the province exclusive authority to

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(55) Canada, Senate, Standing Committee on Fisheries, The Marketing of Fish in Canada: an Interim Report on the Freshwater Fisheries, the Hon. Jack Marshall, Chairman, Ottawa, September 1986, p. 34-35.

(56) Robert Bott, "Net Profits", Canadian Business, Vol. 59, No. 2, February 1986, p. 20.

(57) Aquaculture Association of Canada, Program and Abstracts, Guelph, June 1986, 35 p.

issue licences to aquaculture enterprises, on condition that these meet the federal government's requirements regarding fisheries and other related matters.(58) Even given the regional differences in our vast country, more federal-provincial agreements aimed at promoting the commercial development of aquaculture should materialize before long.

As a postscript, there is no doubt that in any discussion of the development of aquaculture in Canada it is crucial to bear in mind in the present goals of the industry and of governments in this field. These are:

- to encourage the development of commercial aquaculture in Canada in a manner that is complementary to the continuing development of the wild fishery;
- to increase the economic returns from intensified production and harvest of high value, marketable species of fin fish, shell fish and marine plants in the regions of Canada;
- to improve the quality and expand the variety of Canadian fish products;
- to improve the reliability of supply of Canadian products to be marketed in Canada and abroad;
- to create new employment and enriched income opportunities in the production of fish;
- to encourage long-range stability in the country's fish production sector through diversity and continuity of supply; and
- to promote the development and application of the most advanced technologies for intensive production and marketing of fin fish, shell fish and marine plants across Canada.(59)

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(58) Canada, Department of Fisheries and Oceans, and Nova Scotia, Department of Fisheries, Agreement for Commercial Aquaculture Development, March 1986, 6 p.

(59) Canada, Department of Fisheries and Oceans, National Policy Goals for Canadian Aquaculture, Winnipeg, June 9, 1986, p. 1-2.

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